South Carolina
End-of-Course Examination Program

Teacher's Guide

Physical Science Examination

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DRAFT

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Introduction

The South Carolina Education Accountability Act (EAA) of 1998 requires that end-of-course examinations be administered to students in gateway courses. In order to fulfill this EAA mandate, the State Department of Education (SDE) has instituted the South Carolina End-of-Course Examination Program (EOCEP).

The purposes and uses of the EOCEP tests are as follows:

A. The tests promote instruction in specific academic standards for the particular courses, encourage higher levels of student achievement, and document the level of students' mastery of the curriculum standards.

B. The tests serve as indicators of program, school, and school district effectiveness in the manner prescribed by the Education Oversight Committee in accordance with the provisions of the EAA.

C. The tests are weighted 20 percent in the determination of students' final grades in the gateway courses.

The South Carolina end-of-course examinations are multiple-choice tests based on written test specifications that are directly linked to the South Carolina curriculum standards. The test questions are designed and constructed to specifically assess the skills, abilities, and/or knowledge referenced in the standards. Care is taken in creating possible responses so that each question has one correct answer and three incorrect options that represent common errors in reasoning. The test questions are not meant to be tricky; rather, they are designed to distinguish between those students who understand the concept or skill being tested and can apply their understanding, and those students who have an incomplete understanding of the concept. Students who understand the concept will likely choose the correct option, while those with an incomplete understanding are more likely to choose an incorrect, but plausible, option that is based on a common misconception.

All test questions are carefully reviewed by content experts, language and testing experts, and South Carolina Content Review Committee members to ensure that each test question properly measures the intended standard. Test questions are also carefully reviewed so that test-wise students cannot find unintended clues to the correct option. In addition, the South Carolina Sensitivity Review Committee scrutinizes the test to ensure that each question is free from bias with respect to race, gender, ethnicity, socioeconomic status, culture, and geographic region as well as content that would be offensive to any cultural, religious, or ethnic group. The items are then field-tested to further ensure item validity.

This teacher's guide has been developed to provide educators with important information about the EOCEP and to explain how it can be used effectively to strengthen teaching and learning in South Carolina. The guide provides a description of the test that encompasses its purpose and structure, its role in the EOCEP, and the course standards that guided its development. In addition, the guide provides sample questions and practical suggestions about how to prepare students for the examination.

The curriculum standards for the end-of-course examinations can be found at the Department of Education Web site:

http://www.myscschools.com/offices/cso/Science/standards/physical_science_course_standards.pdf

The State Board of Education regulation concerning the EOCEP (R 43-262.4, "End-of-Course Tests"), can be found on the Office of Assessment's Web site:

http://www.myschools.com/offices/assessment/programs/endofcourse/index.htm

A brief summary of the major components of the EAA is provided on the SDE's Web site:

http://www.sde.state.sc.us/archive/ednews/1998/98accact.htm

Part 1

Overview of the Examination

The test questions on the Physical Science examination are aligned with the South Carolina Physical Science course standards and are designed to assess students' mastery of these standards. These course standards—and therefore the examination questions—encompass Inquiry, Physical Science-Chemistry, and Physical Science-Physics. (See Appendix A for the complete text of the Physical Science course standards.)

The Physical Science examination is composed of fifty-five multiple-choice test items. Students are given sufficient time in the testing session to attempt every question on the test.

Basic Questions Teachers Have About the Examination and the EOCEP

Who decided what the examination covers?

The examination is based on the Physical Science course standards that are set forth in the *South Carolina Science Curriculum Standards 2000*. A committee of South Carolina educators and leaders developed these standards; questions to measure students' mastery of these standards were developed specifically for this examination.

Who takes this examination?

The examinations developed and administered through the EOCEP test the curriculum standards addressed in Algebra 1/Mathematics for the Technologies 2, English 1, Physical Science, Biology 1/Applied Biology 2, and U.S. History and Constitution. Students (high school, adult education, or home school) enrolled in these courses or any other courses that address these curriculum standards must take the corresponding test. The test is a requirement regardless of whether the course is unit bearing.

When do students take the test?

Students take the test at the completion of the course. Each district determines a testing schedule within parameters set by the state.

How are home school students tested?

The end-of-course tests are part of the statewide testing program, and home school students approved by the district are required to participate. Students take the test during the first scheduled administration following completion of the course.

Why do students have to take the examination?

The EAA requires the development of end-of-course examinations in the gateway courses. These examinations serve as indicators of program, school, and school district effectiveness, promote instruction in specific academic standards, and encourage higher levels of student achievement. They may be used as final examinations for these courses. The test scores must comprise 20 percent of the students' final grades in these courses.

What accommodations are offered for students with disabilities?

Accommodations, modifications, and customized materials are available for the EOCEP for students with documented disabilities. For South Carolina assessment programs, the term "accommodation" is defined as a change in the testing environment, procedures, or presentation that does not alter in any significant way what the test measures and does not affect the comparability of scores. The purpose of accommodations is to enable students to participate in testing in a way that allows knowledge and skills to be assessed rather than disabilities.

The following are examples of permissible testing accommodations:

- small-group or individual administration;
- extended time, afternoon administration, frequent breaks in testing;
- highlighting, cues, reading aloud to self, repeating/signing directions, oral/signed administration, and customized forms;
- administration of the test over several sessions or several days;
- special lighting or furniture; supplemental materials and devices, and;
- alternate response modes, such as responding in the test booklets, using bold-lined paper, typing responses, and nonverbal responses.

Modifications are available as appropriate. The term "modification" refers to any change in the testing process that compromises the validity and alters the meaning and comparability of the test scores. Modifications are appropriate only for those students with disabilities who, owing to the nature of their disabilities, are unable to take the examination without modifications. The testing modifications should be the same as the modifications used by the students in routine instruction and assessment.

Appropriate customized materials such as large-print, braille, and script versions will be available, as needed, for operational (i.e., non-field test) administrations of the end-of-course examinations.

Is a calculator allowed during testing?

The EOCEP calculator policy for Physical Science appears on the Office of Assessment's Web page:

http://www.myscschools.com/offices/assessment//Programs/endofcourse/CalculatorUsePolicy.htm

It states:

> "Calculators may not be used for the Physical Science test. Test questions are written so that a calculator is not necessary."

However, students with documented disabilities may use calculators as an accommodation, provided that the student uses calculators regularly during routine instruction of physical science. The use of a calculator for mathematical computation support must be documented in the student's IEP or 504 plan.

Is the test timed?

The test is not timed. It is administered in a test session of approximately ninety minutes, which should be sufficient for all students to have the opportunity to attempt every question on the test. Test administrators are instructed to make every effort to give students sufficient time to complete the test.

How are the scores from the EOCEP factored into students' grades?

The results of the EOCEP examination will be used as 20 percent of a student's final grade in the course. Individual EOCEP scores are reported based on the South Carolina uniform grading scale. The score reported is a scale score and not the percent correct.

As a teacher, what are my responsibilities with regard to the EOCEP?

On the first day of class, all students taking a course assessed by the EOCEP must receive a copy of the academic standards for that course. In addition, students taking a Physical Science course should receive copies of the Physical Science equation reference sheet and the Periodic Table of the Elements that appear in the examination booklet. The Physical Science equation reference sheet contains only the equations that may be needed to answer questions on the Physical Science examination.[1] Teachers should incorporate the standards and the appropriate course content into their classroom curriculum, and they should thoroughly familiarize the students with the reference materials. Part 2 of this guide contains sample examination questions intended to help you and your students become familiar with the style of the questions on the test.

The primary responsibility of teachers with regard to the EOCEP is preparing their students for the test by ensuring that they acquire the concepts and skills addressed in the relevant course

[1] The concepts embodied by the equations should not be considered as the only ones taught in a Physical Science course.

standards. Students are expected to have mastered the skills associated with inquiry and to understand the major concepts of Physical Science.[2] Ongoing daily teaching strategies such as hands-on investigations that involve identifying questions, hypothesizing, collecting, displaying, and analyzing data, as well as asking probing questions, requiring written explanations, and initiating student-teacher and student-student dialogue, contribute to this conceptual understanding more constructively than multiple-choice practice questions.

What documents are available to help me prepare my students for the Physical Science examination?

Physical Science Course standards (see Appendix A)

Physical Science Course Guides/Competencies lists the standards along with performance competencies, and suggest strategies, activities, and labs to meet these competencies. This document can be found on the SDE Web site:

http://www.myscschools.com/offices/cso/Standards/Science/Course Standards.cfm

Taxonomy of Cognitive Domains (see Appendix B). This document describes the three cognitive domains—factual knowledge, conceptual understanding, and reasoning and analysis that were used for item construction.

Periodic Table of the Elements. This document is identical to the one that is in the assessment booklet. It can be found on the SDE Web site:

http://www.myscschools.com/offices/assessment/Programs/endofcourse/index.htm

Physical Science Equation Reference Sheet. This document is identical to the one that is in the assessment booklet. It can be found on the SDE Web site:

http://www.myscschools.com/offices/assessment/Programs/endofcourse/index.htm

The blueprint for the South Carolina End-of-Course Examination Program (EOCEP), Physical Science, discusses the construction of the test and gives the approximate number of items in each of the domains and sub-domains. This document can be found on the SDE Web site:

http://www.myscschools.com/offices/assessment/Programs/endofcourse/index.htm

Science Curriculum Standards K–8 outlines the standards that are taught from kindergarten through grade eight and indicate what students should know and be able to do prior to entering high school. This document can be found on the SDE Web site:

http://www.myscschools.com/offices/cso/Science/Sciencef/K8ScienceStandards.doc

[2] The Physical Science course standards can be found in Appendix A.

Part 2

Sample EOCEP Physical Science Test Questions

This section contains sample test items that are representative of the questions used on the Physical Science end-of-course examination. These questions are only a sample of what students should expect to encounter on the actual examination. The items illustrate the format, type, and approximate level of difficulty of the examination questions. For each sample question, the Inquiry, Chemistry, or Physics strand, substrand, and standard are identified. The text describes the content the item is testing, what the student should know to be able to answer the item, and an explanation of the correct and incorrect answers. Where it is relevant, reference is made to the Periodic Table of the Elements or equation reference sheet. In addition, information is included regarding other concepts that may be measured by the standard.

It is important to remember that different forms of the examination will contain different items that assess the same standard. In addition, different forms will contain items within each strand and substrand that assess different standards. The complete listing of the Physical Science course standards appears in Appendix A.

SAMPLE QUESTION 1

Strand: I. Inquiry

Primary Substrand: A. Identify Questions and Concepts that Guide Scientific Investigations

Standard: 1. Demonstrate an understanding of the process of developing scientific hypotheses (e.g., formulate a testable hypothesis based on literature research and prior knowledge, select the correct form for a hypothesis statement based on a given scenario).

Secondary Substrand: B. Design and Conduct Investigations

Standard 1. Demonstrate an understanding of the process of testing scientific hypotheses (e.g., design and conduct a scientific investigation based on the major concepts in the area being studied).

Strand: II. Chemistry

Substrand: B. Structure and Properties of Matter

Standard: 4. The physical properties of a compound reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

b. Identify factors that affect the rates at which substances dissolve.

Cognitive Domain: Reasoning and Analysis

Olivia has three 250 mL flasks containing clear solutions of sodium nitrate in water at 20° C. Each flask contains a different concentration of sodium nitrate. She adds a small crystal of sodium nitrate to each flask and stirs each one for 30 seconds.

Her observations follow.

Flask	Observation
I	The added crystal does not dissolve.
II	The added crystal completely dissolves.
III	The added crystal grows in size.

Which hypothesis is Olivia investigating?

A. Crystal size affects the rate at which sodium nitrate dissolves.
B. Stirring affects the rate at which sodium nitrate dissolves.
C. Concentration affects how much sodium nitrate dissolves.
D. Temperature affects how much sodium nitrate dissolves.

Key: C

Although the context for this question is standard II.B.4.b. the question does not require specific content knowledge, but rather an understanding of inquiry. In order to answer this question, students must demonstrate an understanding of the process of developing scientific hypotheses based on a given scenario. They must be able to process the information given in the setup, as well as interpret the data. Students should recognize the factors that are kept constant (stirring and temperature) and know that the concentration of sodium nitrate in each flask is different. In flask I the solution is saturated, since no more sodium nitrate dissolved. The solution in flask II was less concentrated since the added crystal dissolved and flask III contains the most concentrated solution since the sodium nitrate came out of solution. Therefore, Option C, concentration affects how much sodium nitrate dissolves, is the correct answer.

- Options A, B and D refer to controlled variables and would not be part of a hypothesis. The sodium nitrate crystal was the same size, each flask was stirred, and the temperature of the water was 20° C.

Other items for standards I.A.1. and I.B.1. may ask students to identify a testable hypothesis or question, evaluate characteristics of a well-designed scientific investigation, explain how to improve experimental design, and identify relevant controls or variables. Items for standard II.B.4.b. may ask students to identify the factors that affect the rate at which substances dissolve and to identify and explain the factors that affect the solubility of a substance.

SAMPLE QUESTION 2

Strand: I. Inquiry

Substrand: C. Use Technology and Mathematics to Improve Investigations and Communications

Standard: 3. Select and use mathematical formulas and calculations to express and interpret laboratory measurements.

8. Perform calculations using numbers expressed in scientific notation.

Strand: III Physics

Substrand: C. Interactions of Energy and Matter

Standard: 1. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

a. Identify and show relationships among wave characteristics such as velocity, period, frequency, amplitude, and wavelength using the formula, $v=f\lambda$.

Cognitive Domain: Reasoning and Analysis

X-rays travel at the speed of light: $3 \times 10^8 \frac{m}{s}$. What is the frequency of a wave having the wavelength 2×10^{-7} m?

A. 1.5×10^{-1} Hz
B. 1.5×10^{1} Hz
C. 1.5×10^{-15} Hz
D. 1.5×10^{15} Hz

Key: D

This item requires students to calculate the frequency of a wave given its speed (velocity) and its wavelength and understand how to calculate using numbers written in scientific notation. Students are able to reference the equation for calculating frequency on the equation reference sheet under waves ($v = f\lambda$). Since they are asked for frequency, students must know how to manipulate the variables such that $f = v/\lambda$. They must also know how to multiply and divide exponential numbers (scientific notation). Students are given the values for velocity and wavelength and must divide the velocity by the wavelength to calculate the frequency, as shown below. When dividing terms involving like bases and exponents, the exponents are subtracted. Since the exponent of 10^8 is +8 and the exponent of 10^{-7} is -7, +8- (-7) = 15, i.e. 10^{15}

$$f = \frac{3 \times 10^8 \frac{m}{s}}{2 \times 10^{-7} \text{ m}} = 1.5 \times 10^{15} \text{ Hertz}$$

The key is D.

- Options A, B, and C, all show misconceptions involving exponents and the division of terms.

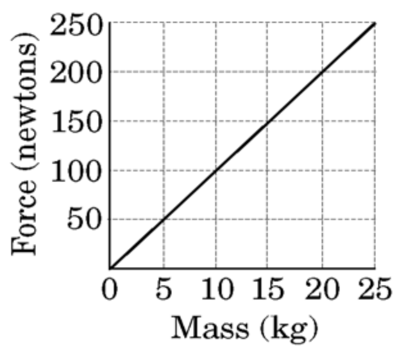
Other items for the standard III.C.1.a. may ask students to identify the characteristics of waves, relate amplitude to energy, and relate period to frequency.

SAMPLE QUESTION 3

Strand:	I.	Inquiry
Primary Substrand:	C.	Use Technology and Mathematics to Improve Investigations and Communications
Standard:	6.	Calculate the slope of the curve and use correct units for the value of the slope for linear relationships.
Secondary Substrand:	B.	Design and Conduct Investigations
	7.	Draw conclusions based on qualitative data and/or quantitative data.

Cognitive Domain: Reasoning and Analysis

Kylie is given this graph of mass and force at a certain acceleration.



Which conclusion can be made about the graph?

A. The acceleration is constant at 0.1 $\frac{m}{s^2}$.
B. The acceleration is constant at 5 $\frac{m}{s^2}$.
C. The acceleration is constant at 10 $\frac{m}{s^2}$.
D. The acceleration is constant at 250 $\frac{m}{s^2}$.

Key: C

This item requires students to understand that the acceleration of an object can be determined by dividing force by mass. The equation for finding acceleration can be found on the equation reference sheet under force and motion (F = ma). Since the graph is linear, the acceleration at any point along the graph will be the same. Thus, if 250 newtons are divided by 25 kg, the answer is 10 $\frac{m}{s^2}$. Option C, therefore, is the correct answer.

- Options A, B, and D are all incorrect because the values for acceleration are not calculated correctly.

Other items for this standard may ask students to draw valid conclusions based on qualitative and quantitative data, evaluate evidence for a given conclusion, make inferences from data sets, and evaluate data in tables and charts.

SAMPLE QUESTION 4

Strand: II. Chemistry

Substrand: A. Structure of Atoms

Standard: 2. The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.

b. Identify the charge, component particles, and mass of the nucleus.

Cognitive Domain: Conceptual Understanding

What is the mass of the nucleus of the most common type of hydrogen atom?

A. the mass of one proton
B. the mass of one electron
C. the sum of the masses of one proton and one neutron
D. the difference in the masses of one proton and one neutron

Key: A

This item requires students to know how to determine the mass of the most common type of hydrogen atom. Students must know that the atomic number of an atom is equal to the number of protons and that the atomic mass is equal to the number of protons plus neutrons. Looking at the periodic table, it can be seen that the atomic number of hydrogen is 1 and the average atomic mass is 1.01. Since the atomic number is approximately equal to the average atomic mass, the most common type of hydrogen atom cannot contain any neutrons, making the correct answer option A—the mass of one proton.

- Options B and D show a misconception about the meaning of atomic mass; and

- Option C, the sum of the masses of one proton and one neutron, is correct for an *isotope* of hydrogen, such as deuterium, but not for the most common type of hydrogen atom.

Other items for this standard may ask students to identify the charge and relative masses of protons and neutrons.

SAMPLE QUESTION 5

Strand: II. Chemistry

Substrand: A. Structure of Atoms

Standard: 2. The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.

d. Demonstrate the understanding that the number of protons identifies an element and is the same for all atoms of that element.

Cognitive Domain: Conceptual Understanding

Wanda learned that deuterium has one proton and one neutron, and that hydrogen has one proton and no neutrons. She concluded that deuterium and hydrogen are two different elements.

Is this a valid conclusion?

A. No; because the number of neutrons only changes the atomic number.
B. Yes; because changing the number of neutrons creates a new element.
C. No; because the number of neutrons does not change the atomic number of an element.
D. Yes; because the number of neutrons changes the chemical properties of an element.

Key: C

This item requires students to know that elements are classified according to the number of protons in the nucleus, and that the atomic number of an element is equal to the number of protons. Since both deuterium and hydrogen have the same number of protons, they must be the same element. The inclusion of neutrons merely makes the atom heavier. Option C is the correct answer.

- Option A incorrectly states that the number of neutrons changes the atomic number. The number of neutrons changes only the atomic mass and does not create new elements.

- Option B is also incorrect. The number of neutrons does change the atomic mass, but new elements are not formed.

- Option D is incorrect because the number of protons (and, therefore, electrons) determines the chemical properties of an element, not the number of neutrons.

Other items for this standard may ask students to use atomic numbers to determine the number of protons in an atom.

SAMPLE QUESTION 6

Strand: II. Chemistry

Substrand: B. Structure and Properties of Matter

Standard: 1. Atoms interact with one another by transferring or sharing electrons that are farthest from the nucleus. These outer electrons govern the chemical properties of the element.

a. Determine the charge a representative element will acquire based on its outer electron arrangement.

Cognitive Domain: Conceptual Understanding

Which equation correctly shows the formation of a barium ion from elemental barium?

A. $Ba + e^- \rightarrow Ba^{1-}$

B. $Ba + 2e^- \rightarrow Ba^{2-}$

C. $Ba \rightarrow Ba^{1-} + e^-$

D. $Ba \rightarrow Ba^{2+} + 2e^-$

Key: D

This item requires students to recognize the equation that correctly shows the formation of a barium ion. Students need to read the periodic table, recognize the symbols for ions and electrons, and realize that when elements become ions they either gain or lose electrons, depending on the number of electrons in their outer orbits.
Option D is correct because Barium is a group 2 element and has two electrons in its outer orbit. It will lose two electrons when forming an ion. Electrons have a negative charge. When a barium atom loses two electrons, it will have two more protons than electrons, and the atom will have a net positive charge. The equation correctly shows the release of 2 electrons. The barium ion now has a charge of +2 because it has two more protons than electrons.

- Options A and B show the barium atom gaining electrons instead of losing them. Both options are incorrect.

- Option C shows barium losing only one of the two electrons in its outer orbit and is incorrect.

Other items for this standard may ask students to identify the charge on an atom when it gains or loses an electron, to explain that nonmetallic elements tend to gain one or more electrons and metallic elements tend to lose one or more electrons, and to use electron diagrams to determine which atoms will gain or lose electrons and the charge of the resulting ion.

SAMPLE QUESTION 7

Strand: II. Chemistry

Substrand: B. Structure and Properties of Matter

Standard: 2. An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This “Periodic Table” is a consequence of the repeating pattern of the outermost electrons and their permitted energies.

c. Explain that property trends on the periodic table are a function of the elements’ atomic structures.

Cognitive Domain: Conceptual Understanding

Use the periodic table to determine which element is **least** likely to give away electrons.

A. boron
B. lithium
C. calcium
D. neon

Key: D

This item requires students to know the importance of the groupings, as shown on the periodic table, to determine which element is least likely to give away electrons. They need to know that when elements react to form compounds they either give away, attract or share electrons in order to achieve an outer electron shell that is complete (i.e., contain the maximum allowable electrons). Elements with one, two, or three, electrons in their outer shells tend to give them away. Those with four tend to share them, and those with more than four tend to attract them. Option D (neon - Group 18) is the least likely to give away electrons since its outer electron shell already holds eight electrons and is complete. It is considered an inert or noble gas.

- Group 13 elements (option A – boron) have three electrons in their outer shell. They tend to give these away.

- Group 1 elements (option B – lithium) are very reactive since they have only one electron in their outer shell, which they tend to readily give away.

- Group 2 elements (option C – calcium) have two electrons in their outer shell and also tend to give the electrons away.

Other items for this standard may ask students to explain that elements in the periodic table are arranged by atomic number, to understand the outer shell of electrons is important in determining the physical and chemical properties of an element, and to compare and contrast the properties of metals and nonmetals.

SAMPLE QUESTION 8

Strand: II. Chemistry

Substrand: B. Structure and Properties of Matter

Standard: 3. Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.

b. Classify compounds as being ionic or covalent on the basis of the transferring or sharing of outer electrons.

c. Determine the ratio by which elements combine to form ionic compounds and express that ratio in a chemical formula.

Cognitive Domain: Conceptual Understanding

Which of the following is a covalent compound?

A. CO_2
B. K_2O
C. NaCl
D. $MgCl_2$

Key: A

This item requires students to know which elements are likely to form ionic or covalent compounds. Students can use the Periodic Table of the Elements to help them determine the correct answer.
Option A is the correct answer since a carbon atom has four electrons in its outer orbit and an oxygen atom has six electrons in its outer orbit. Each oxygen atom shares two electrons with carbon to form two carbon-oxygen double bonds. Carbon now has a complete outer orbit of eight electrons as do each of the oxygen atoms.

- Option B is made up of potassium and oxygen. Potassium is in group 1 and has one electron in its outer shell. Oxygen has six electrons in its outer shell and needs eight to make a complete shell. Each atom of potassium donates one electron to oxygen. Oxygen will then have a negative charge and potassium a positive charge. This is an example of an ionic compound and is incorrect.

- In option C, students should recognize that sodium is in group 1, and chlorine is in group 17. Sodium has one electron in its outer orbit and chlorine has seven. Sodium gives one electron to chlorine becoming positively charged, while chlorine becomes negatively charged, forming an ionic compound.

- Option D, magnesium chloride, is also an ionic compound. Magnesium is an element in group 2 and has two electrons in its outer orbit. It gives away these two electrons, one to each of two chlorine atoms. Thus their orbits are now stable with eight electrons, and potassium is stable with eight electrons in its outer orbit.

Other items for this standard may ask students to predict which atoms become anions and cations in an ionic bond and to explain the concepts of double and triple bonds.

SAMPLE QUESTION 9

Strand: II. Chemistry

Substrand: C. Chemical Reactions

Standard: 3. A large number of important reactions involve the transfer of either electrons (oxidation/reduction) or hydrogen ions (acid/base reactions) between reaction ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

a. Differentiate between acids and bases.

1. Identify the physical and chemical characteristics of acids and bases, includin their formulas, reactions with metals, and pH.

Cognitive Domain: Conceptual Understanding

Which equation represents a neutralization (acid-base) reaction?

A. $4Fe + 3O_2 \rightarrow 2Fe_2O_3$
B. $CaCO_3 \rightarrow CaO + CO_2$
C. $NaOH + HCl \rightarrow NaCl + H_2O$
D. $Mg + 2HCl \rightarrow MgCl_2 + H_2$

Key: C.

This item requires students to recognize a neutralization reaction, i.e., a reaction between an acid and a base to produce a salt and water. Students should be able to identify an acid or a base by its formula, and should also recognize the symbols of elements (these can be found on the periodic table) as well as the formulas for some common compounds such as water and salt. .
Option C, the correct answer, is the only neutralization reaction. Sodium hydroxide (a base) reacts with hydrochloric acid (an acid) to produce sodium chloride (a salt) and water.

- In option A, iron is oxidized to form rust, which is not a neutralization reaction.
- Option B represents decomposition and shows calcium carbonate breaking down to form calcium oxide and carbon dioxide.
- Option D shows the reaction between a metal and an acid with the production of a salt, magnesium chloride, and hydrogen gas.

Other items for this standard may ask students to explain the physical and chemical properties of acids and bases, identify the chemical formulas of common acids and bases, identify the products of a reaction between an acid and a metal and a base and a metal, and explain the effects of acids and bases on litmus paper.

SAMPLE QUESTION 10

Strand: II. Chemistry

Substrand: C. Chemical Reactions

Standard: 2. Chemical reactions may release or consume energy. Some reactions such as the burning of fossil fuels release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions such as photosynthesis and the evolution of urban smog.

d. Conclude from experimental evidence, based on mass measurements, that mass is neither created nor destroyed during ordinary chemical reactions (e.g., balance simple synthesis and decomposition equations, conduct mass measurements before and after reactions).

Cognitive Domain: Conceptual Understanding

Does the law of conservation of mass apply to the burning of wood?

A. No, because the mass of the ashes produced by burning is less than the original mass of the wood.
B. Yes, because the mass of all the products of burning is equal to the original mass of the wood.
C. No, because energy is created while burning, there is a loss of mass.
D. Yes, because the energy produced is also considered while balancing mass.

Key: B

This item requires students to understand that matter cannot be created or destroyed in ordinary chemical reactions. Students must recognize that the mass of the wood before burning has to equal the mass of the products after burning. Thus option B is the correct answer.

- Options A and C both indicate that the law of conservation of mass does not apply to burning wood; therefore they are incorrect.

- Option D is incorrect because the energy produced is not considered while balancing mass, just the products.

Other items for this standard may ask students to balance simple synthesis and decomposition equations and predict the mass of products and reactants in a chemical reaction.

SAMPLE QUESTION 11

Strand: III. Physics

Substrand: A. Motion and Forces

Standard: 1. Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

d. Evaluate the effects of action/reaction in terms of Newton's third law.

Cognitive Domain: Conceptual Understanding

Amani was jumping rope. Which of Newton's laws is most closely associated with how Amani was able to get her body off the ground?

A. An object at rest remains at rest until an unbalanced force acts on it.
B. An object's acceleration is directly proportional to the force acting on it.
C. An object exerts an equal and opposite force on another object.
D. An object's gravitational force causes an object to fall back towards the Earth.

Key: C

This item requires students to identify examples associated with Newton's laws of motion. Option C, paraphrases Newton's third law of motion and is the correct answer. The force Amani exerts on the ground is equal to the force the ground exerts on Amani. When Amani pushes on the ground it is an action force and the equilibrium between the two forces is unbalanced. The reaction of the ground pushing up on her feet is what makes her jump up.

- Option A is Newton's first law of motion. Since there is no unbalanced, external force propelling Amani up, Newton's first law does not apply.

- Option B is Newton's second law of motion. It is also incorrect, since there is no acceleration caused by an external force.

- Option D, an object's gravitational force causes an object to fall back towards the Earth, is an example of what happens to Amani after she has jumped and is incorrect.

Other items for this standard may ask students to identify examples of Newton's third law and analyze diagrams to determine the forces on an object.

SAMPLE QUESTION 12

Strand: III. Physics

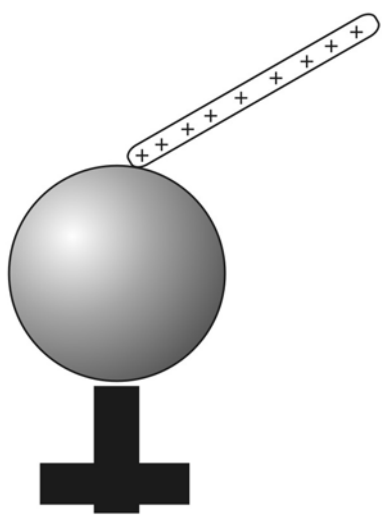
Substrand: A. Motion and Forces

Standard: 3. The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them. Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces such as those exerted by a coiled spring or friction may be traced to electric forces acting between atoms and molecules.

b. Demonstrate an understanding of the production and effects of static electricity (e.g., its role in disruptions and damage to electrical devices, destruction of property and life, everyday annoyances such as static cling).

Cognitive Domain: Conceptual Understanding

A positively charged glass rod touches a metal sphere placed on an insulated stand, as shown in the diagram.



Why does the metal sphere acquire a positive charge?

A. Electrons move from the glass rod to the metal sphere.
B. Electrons move from the metal sphere to the glass rod.
C. Protons move from the glass rod to the metal sphere.
D. Protons move from the metal sphere to the glass rod.

Key: B

This item requires students to understand the concept of static electricity, and to know that movement of electrons causes objects to become negatively or positively charged. The glass rod is positively charged because it has more protons than electrons and will attract electrons from the metal sphere. When electrons move from the sphere to the rod the metal sphere will have acquired a positive charge. Therefore, option B is the correct answer.

- Option A is incorrect because the metal sphere would acquire a negative charge not a positive charge if electrons moved from the glass rod to the metal sphere.

- Options C and D are incorrect because protons never move from one atom to another. They are part of the nucleus of an atom and are never conducted as individual particles.

Other items for this standard may ask students to explain how static electricity is produced, identify what happens when there is a build up of charge, explain how lightning is produced and discharged, and relate the effects of static electricity to everyday situations.

SAMPLE QUESTION 13

Strand: III. Physics

Substrand: B. Conservation of Energy and the Increase in Disorder

Standard: 1. The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

a. Analyze transformations between potential and kinetic energies.

Cognitive Domain: Conceptual Understanding

Ryan is playing with a ball. When would the ball have the **greatest** potential energy?

A. when Ryan holds the ball behind his shoulder and prepares to throw it
B. when Ryan catches the ball above his head while standing still
C. when Ryan runs down the field with the ball under his arm
D. when Ryan kicks the ball along the ground

Key: B

This item requires students to understand the concept of potential energy. They must know that potential energy is energy of position. It depends on mass, acceleration due to gravity, and height. Students can find the formula for potential energy on the equation reference sheet under energy, work, power, and efficiency—PE = m*g*h. Option B is the correct answer because the height of the ball is greater above his head than behind his shoulder.

- The ball in option A has potential energy, but its potential energy is less than the ball in option B because its height is lower.

- In options C and D the ball has kinetic energy, not potential energy, since the ball is moving in both instances.

Other items for this standard may ask students to distinguish between potential energy and kinetic energy and to analyze transformations between them.

SAMPLE QUESTION 14

Strand: III. Physics

Substrand: B. Conservation of Energy and the Increase in Disorder

Standard: 1. The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

c. State and apply quantitative relationships among energy, work, power, and efficiency.

Cognitive Domain: Conceptual Understanding

Helen's car is being lifted onto the back of a tow truck. The towing platform is a distance of 1.5 meters from the ground.

If the car has a mass of 900 kilograms, approximately how much work is required to lift the car?

Work in joules = force in newtons $\times$ distance in meters. W = Fd

A. 600 J
B. 1350 J
C. 6000 J
D. 13,500 J

Key: D

This item requires students to calculate work, given the scenario of a car being lifted onto a tow truck. The equation for work is given on the equation reference sheet under energy, work, power, and efficiency.

W = Fd, where W = work (joules, J), F = force (newtons, N), and d = distance (meters, m). Students must also realize that force is equal to mass $\times$ gravitational acceleration (9.8 $\frac{\mathrm{m}}{\mathrm{s}^2}$).

In this item force = 9.8 $\frac{\mathrm{m}}{\mathrm{s}^2}$ $\times$ 900 kg (mass of car). Rounding 9.8 $\frac{\mathrm{m}}{\mathrm{s}^2}$ to 10 $\frac{\mathrm{m}}{\mathrm{s}^2}$ and multiplying by 900 kg = 9,000 newtons.

Since Work = force $\times$ distance
Work = 9,000 newtons $\times$ 1.5 meters
Work = 13,500 joules

Option D is the correct option.

Other items for this standard may ask students to apply the correct formula to problems involving energy, work, power, and efficiency or use tabular data to determine energy, work, power and efficiency.

SAMPLE QUESTION 15

Strand: III. Physics

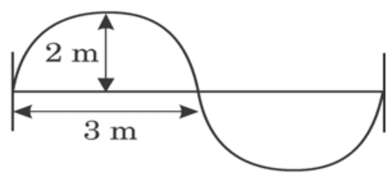
Substrand: C. Interactions of Energy and Matter

Standard: 1. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

a. Identify and show relationships among wave characteristics such as velocity, period, frequency, amplitude, and wavelength using the formula, $v=f\lambda$.

Cognitive Domain: Factual Knowledge

The diagram below shows one complete wave cycle.



What is the wavelength in the diagram?

A. 2 m

B. 3 m

C. 4 m

D. 6 m

Key: D

This item requires students to know the parts of a wave. They must know that a wavelength is equal to one complete wave cycle. Students should know that 3 m is equal to half the wavelength, thus 6 m, option D, is the correct answer.

- Option A, 2 m, is the amplitude
- Option A, 3m is one-half the wavelength.
- Option C, 4 m, is twice the amplitude.

Other items for this standard may ask students to relate amplitude to energy, relate period to frequency, and calculate wavelength, frequency, velocity, and period.

Part 3

Preparing Your Students for the Examination

Here are some classroom strategies you can employ to help prepare your students for the Physical Science end-of-course examination.

A. Ensure that your instructional practices are aligned with the examination by
- using the equation reference sheet as a basis for problem solving;
- using the Periodic Table of the Elements;
- using inquiry-based instruction;
- incorporating investigations throughout instruction;
- incorporating ongoing cumulative review on a regular basis;
- using realistic problems, real-world contexts, and current issues to launch instruction and apply the inquiry skills and concepts you are teaching; and
- asking such questions as, "Why?" "How do you know?" "Can you explain?"

B. Ensure that your students are sufficiently familiar with the format of the examination by
- incorporating into your instruction various questions, exercises, and problems that are similar in format and content to the samples in this guide;
- using the equation reference sheet and Periodic Table of the Elements throughout your instruction; and
- adjusting instruction in response to classroom assessment needs.

C. Rather than practicing for the test, incorporate classroom assessments that probe students' understanding by
- focusing on standards-based instruction that incorporates hands-on inquiry and higher level critical thinking strategies; and
- using meaningful classroom assessments that reflect the standards you teach in your classroom.

D. Ensure that your students are sufficiently motivated to take the examination by
- sharing information about the purpose and importance of the examination; and
- sending notes home to enlist parental support for student preparation.

E. Ensure that your course outline is aligned with the examination by
- placing appropriate emphasis on the concepts and skills outlined in the standards and course guides; and
- supplementing the standard textbook with other instructional materials, particularly if specific standards are not adequately covered in the textbook.

Part 4

Raising Student Achievement Levels

You can use these teaching strategies to help raise your students' achievement level on the Physical Science examination.

A. Correlate your course outline with the standards. Become thoroughly familiar with the standards and their relationship to the course outline for Physical Science. If certain standards are not included in your course outline but are assessed on the examination, you should incorporate those standards into your outline. Recommended course guides for Physical Science are available on the SDE Web site:

http://www.myscschools.com/offices/cso/Science/standards/physical_science_course_standards.pdf

B. Collaborate with other teachers in your school. Discussions with science colleagues that systematically review any inconsistencies between what is being taught and which standards are being assessed are critical for aligning curriculum and assessment. After having such discussions, teachers generally are better able to make adjustments in what they emphasize and de-emphasize, what terms they use, and how and when they present specific aspects of the curriculum. Discussions with mathematics teachers to ensure that the skills involved in manipulating and solving equations are reviewed and reinforced are also critical for preparing students for the Physical Science assessment.

C. Incorporate multiple-choice questions and constructed-response questions into your unit tests and quizzes. Since students are already tested and quizzed on an ongoing basis, one of the more straightforward strategies for raising achievement is to ensure that ongoing tests and quizzes include questions that are similar to those that students will face on the end-of-course examination. Generally, well-written multiple-choice items contain, as the alternative options, the most common mistakes that students make. Instead of simply giving your students the correct answers, take time after any test or quiz to explain why they may have selected the incorrect options. Although constructed-response questions are not on the assessment, they are useful tools for good conceptual development.

D. Develop action plans for your department. Every school and every department is different. Strategies that are needed in one place may not be needed in another. Some schools may have already implemented and institutionalized some strategies, and therefore need to focus on others. For these reasons, departments are encouraged to develop their own action plans that reflect existing conditions and needs. Written action plans with objectives, activities, timelines, and assigned responsibilities are effective ways to move forward. Study the results of reports to improve instruction and achievement.

APPENDIX A

Physical Science Course Standards

Course Description

Physical Science is designed to serve as a foundation for other high school science courses. It is a laboratory course (minimum of 30 percent hands-on investigation) that integrates principles of chemistry and physics. It emphasizes inquiry based learning, process skills, and higher-order thinking skills. Chemistry units include composition and classification of matter, atomic structure and the Periodic Table of the Elements, and chemical bonds and reactions, together with basic nuclear chemistry. Physics units include forces and motion; conservation of energy; electricity and magnetism; and wave phenomena, characteristics, and behavior, including electromagnetic and sound waves. Because experimentation is the basis of science, laboratory investigations are an integral part of this course. Investigative, hands-on lab activities that address the high school inquiry standards are central to effective instruction in this course.

Standards in italics describe classroom learning that is essential for students to perform at a high level but that cannot be tested directly on a state assessment because of formatting, bias, technology, and sensitivity issues. However, these standards are appropriate for classroom assessment.

I. Inquiry

Inquiry is not an isolated unit of instruction and should be embedded throughout the content area of Physical Science. The nature of science and technology is incorporated within this area.

A. Identify Questions and Concepts that Guide Scientific Investigations

Experimental design should demonstrate logical connections between a knowledge base and conceptual understanding.

1. Demonstrate an understanding of the process of developing scientific hypotheses (e.g., formulate a testable hypothesis based on literature research and prior knowledge, select the correct form for a hypothesis statement based on a given scenario).
2. Identify and select experimental variables (independent and dependent) and devise methods for controlling relevant conditions.

B. Design and Conduct Investigations

Science builds on prior knowledge; thus prior knowledge about major concepts, laboratory apparatus, laboratory techniques, and safety should be used in designing and conducting a scientific investigation.

1. Demonstrate an understanding of the process of testing scientific hypotheses (e.g., design and conduct a scientific investigation based on the major concepts in the area being studied).
2. Select and use appropriate instruments to make the observations necessary for the investigation, taking into consideration the limitations of the equipment.
3. Select the appropriate safety equipment needed to conduct an investigation (e.g., goggles, aprons) and identify safety precautions for the handling of materials and equipment used in an investigation.
4. Describe the proper response to emergency situations in the laboratory.
5. Identify possible sources of procedural error (e.g., incorrect measurement) and identify appropriate methods of control (e.g., repeated trials, systematic manipulation of variables) in an experimental design.
6. Organize and display data in useable and efficient formats, such as tables, graphs, maps, cross sections, and mathematical expressions.
7. Draw conclusions based on qualitative and/or quantitative data.
8. Discuss the impact of sources of error on experiments.
9. Communicate and defend the scientific thinking that has resulted in conclusions.

C. Use Technology and Mathematics to Improve Investigations and Communications

Scientific investigations can be improved through the use of technology and mathematics. While it is acknowledged that the System International of Units (called the SI system) is the accepted measurement system in science, opportunities to use the U.S. Customary System are encouraged where appropriate.

1. Select and use appropriate technologies (e.g., computers, calculators, calculator-based laboratories [CBLs], electronic balances, calipers) to achieve appropriate precision and accuracy of data collection, analysis, and display.
2. Discriminate between valid and questionable data.
3. Select and use mathematical formulas and calculations to express and interpret laboratory measurements.
4. Demonstrate an understanding of trends and patterns in data (e.g., calculate interpolated data points, predict extrapolated data points) and demonstrate the ability to interpret these phenomena.
5. Draw a “best fit” curve through data points by using computer software and/or graphing calculators.
6. Calculate the slope of the curve and use correct units for the value of the slope for linear relationships.
7. Perform dimensional analysis calculations.
8. Perform calculations using numbers expressed in scientific notation.

D. Formulate and Revise Scientific Explanations and Models Using Logic and Evidence

Scientific explanations and models are developed and revised through discussion and debate.

1. Construct scientific explanations or models (physical, conceptual, and mathematical) by using discussion, debate, logic, and experimental evidence.
2. Develop explanations and models that demonstrate scientific integrity. (P)
3. Revise explanations or models.

E. Recognize and Analyze Alternative Explanations and Models

Scientific criteria are used to discriminate among plausible explanations.

1. Compare current scientific models with experimental results.
2. Select and defend, on the basis of scientific criteria, the most plausible explanation or model.

F. Communicate and Defend a Scientific Argument

Experimental processes, data, and conclusions are communicated in a clear and logical manner.

1. Develop a set of laboratory instructions that someone else can follow.
2. Develop a presentation to communicate the process and the conclusion of a scientific investigation.

G. Understandings About Scientific Inquiry

Historical and current scientific knowledge, current research, technology, mathematics, and logic form the basis for conducting investigations and drawing conclusions.

1. Analyze how science and technology explain and predict relationships.

   a. Defend the idea that conceptual principles and knowledge guide scientific inquiry.
   b. Discuss how the available body of scientific knowledge, historical and current, influences the design, interpretation, and evaluations of investigations.

2. Discuss the reasons why scientists and engineers conduct investigations and the methods they use to conduct these investigations.
3. Demonstrate and discuss the use of technology as a method of enhancing data collection and data manipulation and of advancing the fields of science and technology.
4. Discuss how mathematics is important for scientific inquiry.
5. Discuss why scientific models and explanations need to be based on the available body of scientific knowledge.

6. Demonstrate the understanding that scientific explanations must be logical, supported by the evidence, and open to revision.

II. Physical Science (Chemistry)

A. Structure of Atoms

1. Matter is made of minute particles called atoms, and atoms are composed of even smaller components. These components have measurable properties, such as mass and electrical charge. Each atom has a positively charged nucleus surrounded by negatively charged electrons. The electric force between the nucleus and the electrons holds the atom together.

   a. *Trace the historical development of the model of the atom, including the contributions of John Dalton, J. J. Thomson, Ernest Rutherford, and Neils Bohr. (H, N)*
   b. *Compare and contrast the component particles of the atom.*

2. The atom's nucleus is composed of protons and neutrons, which are much more massive than electrons. When an element has atoms that differ in the number of neutrons, these atoms are called different isotopes of the element.

   a. *Trace the development of nuclear models including the contributions of Marie and Pierre Curie, Lise Meitner, and Enrico Fermi. (H, N)*
   b. *Identify the charge, component particles, and mass of the nucleus.*
   c. *Recognize that elements exist as isotopes, which may be stable or unstable (radioactive).*
   d. *Demonstrate the understanding that the number of protons identifies an element and is the same for all atoms of that element.*

3. The nuclear forces that hold the nucleus of an atom together, at nuclear distances, are usually stronger than the electric forces that would make it fly apart. Nuclear reactions convert a fraction of the mass of interacting particles into energy, and they can release much greater amounts of energy than atomic interactions. Fission is the splitting of a large nucleus into smaller pieces. Fusion is the joining of two nuclei at extremely high temperature and pressure, and is the process responsible for the energy of the sun and other stars.

   a. *Compare and contrast fission and fusion reactions, showing how they are processes that convert matter to energy.*
   b. *Describe fusion as the process that fuels the sun and other stars.*
   c. *Demonstrate an understanding of the consequences of the development of nuclear applications such as the atomic bomb, nuclear power plants, and medical technologies. (P)*

B. Structure and Properties of Matter

1. Atoms interact with one another by transferring or sharing electrons that are farthest from the nucleus. These outer electrons govern the chemical properties of the element.

    a. *Determine the charge a representative element will acquire based on its outer electron arrangement.*

2. An element is composed of a single type of atom. When elements are listed in order according to the number of protons (called the atomic number), repeating patterns of physical and chemical properties identify families of elements with similar properties. This "periodic table" is a consequence of the repeating pattern of outermost electrons and their permitted energies.

    a. *Trace the historical development of the periodic table including the contribution of Dmitri Mendeleev. (H, N)*
    b. *Explain the arrangement of elements within a group on the periodic table based on similar physical and chemical properties.*
    c. *Explain that property trends on the periodic table are a function of the elements' atomic structures.*
    d. *Determine atomic number, mass number, the number of protons, the number of neutrons, and the number of electrons for given isotopes of elements using the periodic table.*

3. Bonds between atoms are created when electrons are paired up by being transferred or shared. A substance composed of a single kind of atom is called an element. The atoms may be bonded together into molecules or crystalline solids. A compound is formed when two or more kinds of atoms bind together chemically.

    a. *Compare and contrast elements and compounds.*
    b. *Classify compounds as being ionic or covalent on the basis of the transferring or sharing of outer electrons.*
    c. *Determine the ratio by which elements combine to form ionic compounds; express that ratio in a chemical formula.*

4. The physical properties of a compound reflect the nature of the interactions among its molecules. These interactions are determined by the structure of the molecule, including the constituent atoms and the distances and angles between them.

    a. *Relate the physical properties (e.g., boiling point, melting point, conductivity) of compounds to their ionic or covalent bonding.*
    b. *Identify factors that affect the rates at which substances dissolve.*
    c. *Compare the ratios of solute to solvent in concentrated and dilute solutions in relation to the physical properties of the solution (e.g., conductivity, melting point depression).*
    d. *Analyze the behavior of polar and nonpolar substances in forming solutions.*

5. Solids, liquids, and gases differ in the distances and angles between molecules or atoms and, therefore, the energy that binds them together. In solids the structure is nearly rigid; in liquids molecules or atoms move around each other but do not move apart; in gases molecules or atoms move almost independently of each other and are mostly far apart.

    a. *Compare and contrast solids, liquids, and gases in terms of particle arrangement and the energy that binds them together.*

6. Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.

    a. *Demonstrate an understanding of how carbon atoms bond to one another as simple hydrocarbons.*
    b. *Describe the formation of polymers.*
    c. *Discuss the importance of polymers as biological compounds such as proteins, carbohydrates, and lipids.*
    d. *Determine the uses of polymers in everyday life.*

C. Chemical Reactions

1. Chemical reactions occur all around us; for example, in health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies.

    a. *Demonstrate an understanding of the process of rusting in terms of electron transfer (e.g., determine the number of electrons lost or gained, write and balance a chemical equation for rusting, discuss the economic impact of rusting).*
    b. *Demonstrate an understanding of how metabolism is an inter-related collection of chemical reactions.*

        1. <u>Demonstrate the understanding that food is composed partially of large complex molecules that are broken down into simpler molecules. (P)</u>
        2. <u>Analyze how these simpler molecules are rearranged into new molecules within living things. (N)</u>

    c. *Explain the sources and environmental effects of some inorganic and organic toxic substances, such as heavy metals and PCBs. (P)*

2. Chemical reactions may release or consume energy. Some reactions, such as the burning of fossil fuels, release large amounts of energy by losing heat and by emitting light. Light can initiate many chemical reactions, such as photosynthesis and the evolution of urban smog.

a. *Investigate and provide evidence of a chemical change by recording systematic observations, such as change in color, odor, and temperature for various chemical reactions. (N)*
b. *Recognize balanced chemical equations.*
c. *Classify reactions as energy-absorbing (endothermic) or energy-releasing (exothermic) on the basis of temperature measurements.*
d. *Conclude from experimental evidence, based on mass measurements, that mass is neither created nor destroyed during ordinary chemical reactions (e.g., balance simple synthesis and decomposition equations, conduct mass measurements before and after reactions). (N)*

3. A large number of important reactions involve the transfer of either electrons (oxidation/reduction) or hydrogen ions (acid/base reactions) between reaction ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes, such as the presence of ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosions.

   a. *Differentiate between acids and bases.*

      1. <u>Identify the physical and chemical characteristics of acids and bases, including their formulas, reactions with metals, and pH.</u>
      2. <u>Determine the pH ranges and strengths of acidic, basic, and neutral solutions using appropriate instruments and indicators (e.g., pH meters, CBL probes, universal indicators).</u>
      3. <u>Explain how acid rain is formed and discuss its effects on the environment. (P)</u>
      4. <u>Demonstrate an understanding of the significance of pH as related to consumer products.</u>

4. Chemical reactions can take place in time periods ranging from the few femtoseconds (10–15 seconds) required for an atom to move a fraction of a chemical bond distance to geologic time scales of billions of years. Reaction rates depend on how often the reacting atoms and molecules encounter one another, on the temperature, and on the properties—including shape—of the reacting species. Catalysts, such as metal surfaces, accelerate chemical reactions. Chemical reactions in living systems are catalyzed by protein molecules called enzymes.

   a. Demonstrate an understanding of how reaction rates are a function of the collisions among particles (i.e., effects of temperature, particle size, stirring, concentration on reaction rates; and the effects of catalysts on reaction rates).
   b. Apply reaction rate concepts to real-life applications such as food spoilage, storage of film and batteries, digestive aids, and catalytic converters. (P, T)

III. Physical Science (Physics)

A. Motions and Forces

1. Objects change their motion only when a net force is applied. Laws of motion are used to calculate precisely the effects of forces on the motion of objects. The magnitude of the change in motion can be calculated using the relationship F = ma, which is independent of the nature of the force. Whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted on the first object.

   a. *Trace the historical development of the understanding of forces, including the contributions of Galileo, Isaac Newton, Benjamin Franklin, and Charles-Augustin de Coulomb. (H, N)*
   b. *Predict the motion of an object in terms of Newton's first law (inertia).*
   c. *Identify and investigate the factors that affect acceleration in terms of Newton's second law (F = ma).*
   d. *Evaluate the effects of action/reaction in terms of Newton's third law.*
   e. *Generate and interpret graphs of linear motion.*
   f. *Cite examples of Newton's laws that are common in everyday life (e.g., using seat belts, diving from a boat, pushing a swing). (P, T)*

2. Gravitation is a universal force that each mass exerts on any other mass. The strength of the gravitational attractive force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.

   a. *Describe changes in gravitational attraction in terms of changes in distances between masses and in terms of changes in the masses.*

3. The electric force is a universal force that exists between any two charged objects. Opposite charges attract while like charges repel. The strength of the force is proportional to the charges, and, as with gravitation, inversely proportional to the square of the distance between them. Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces, such as those exerted by a coiled spring or friction, may be traced to electric forces acting between atoms and molecules.

   a. *Demonstrate the interactions of like and unlike charges by examining changes in electrostatic attraction in terms of changes in distance between two point charges.*
   b. *Demonstrate an understanding of the production and effects of static electricity (e.g., its role in disruptions and damage to electrical devices, destruction of property and life, everyday annoyances such as static cling). (N, P, T)*

4. Electricity and magnetism are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces, and moving magnets produce electric forces. These effects help students to understand electric motors and generators.

a. *Demonstrate an understanding of the relationship between electricity and magnetism (e.g., describe how moving electrical charges produce magnetic fields, describe how moving magnets produce electrical fields).*
b. *Examine the effects of the advent of electricity on individuals and society. (H, N, P, T)*

5. Analyze electrical circuits that obey Ohm's law.

a. *Demonstrate an understanding of simple series and parallel circuits (e.g., construct, compare, contrast, and schematically diagram simple series and parallel circuits).*
b. *Describe the meaning of voltage and amperage.*
c. *Perform calculations using Ohm's law.*
d. *Explain how fuses, surge protectors, and breakers function. (T)*

B. Conservation of Energy and the Increase in Disorder

1. The total energy of the universe is constant. Energy can be transferred by collisions in chemical and nuclear reactions, by light waves and other radiations, and in many other ways. However, it can never be destroyed. As these transfers occur, the matter involved becomes steadily less ordered.

a. *Analyze transformations between potential and kinetic energies.*
b. *Analyze transformations among other forms of energy such as heat, light, and sound, and mechanical, electrical, and chemical energy.*
c. *State and apply quantitative relationships among energy, work, power, and efficiency.*
d. *Understand and apply the principles of mechanical advantage (e.g., contrast the two forces and two distances that produce mechanical advantage when a machine is used to produce work).*

2. All energy can be considered to be either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained by a field, such as electromagnetic waves.

a. *Classify energy types as potential, kinetic, or electromagnetic.*

3. Heat consists of random motion and the vibrations of atoms, molecules, and ions. The higher the temperature, the greater the atomic or molecular motion.

a. *Predict and measure the effects of varying the temperature, pressure, and volume of gases (e.g., balloon studies, the bends in divers, and the hazards of handling and storing pressurized gases. (N, P, T)*
b. *Describe particle motion and distance as the phase changes from liquid to solid to gas.*

4. Everything tends to become less organized and less orderly over time. Thus, in all energy transfers, the overall effect is that the energy is spread out uniformly. Examples are the transfer of energy from hotter to cooler objects by conduction, radiation, or convection and the warming of our surroundings when we burn fuels.

   a. *Demonstrate an understanding of the transfer of energy from hotter to cooler objects by conduction, radiation, and convection.*
   b. *Compare and contrast the environmental impact of power plants that use fossil fuels, water, or nuclear energy to produce electricity. (P, T)*

C. Interactions of Energy and Matter

1. Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

   a. *Identify and show relationships among wave characteristics such as velocity, period, frequency, amplitude, and wavelength using the formula* $v = f\lambda$.
   b. *Compare and contrast models of longitudinal waves (e.g., sound waves, seismic waves) and transverse waves (e.g., electromagnetic waves, water waves).*
   c. *Distinguish among the electromagnetic spectrum, seismic waves, water waves, and sound waves on the basis of their properties and behaviors.*
   d. *Demonstrate an understanding of factors affecting wave energy (wavelength, amplitude, and frequency) and its effects on everyday life (e.g., health issues, medical diagnostics and treatments).*

2. Electromagnetic waves result when a charged object is accelerated or decelerated. Electromagnetic waves include radio waves (the longest wavelength), microwaves, infrared radiation (radiant heat), visible light, ultraviolet radiation, x-rays, and gamma rays. The energy of electromagnetic waves is carried in packets whose magnitude is inversely proportional to the wavelength.

   a. *Compare and contrast the parts of the electromagnetic spectrum in terms of velocity, wavelength, frequency, and energy using the formula* $v = f\lambda$.

3. Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

   a. *Demonstrate an understanding of how the releasing of energy by electrons produces light (e.g., fireworks, neon lights, florescent lights, halogen lights).*

4. In some materials, such as metals, electrons flow easily, whereas in insulating materials such as glass they can hardly flow at all. Semiconducting materials have intermediate behavior. At low temperatures, some materials become superconductors and offer no resistance to the flow of electrons.

a. *Understand and compare the functions of insulators, conductors, and semiconductors.*
b. *Evaluate the impact of the miniaturization of electric circuits upon individuals and society.*

Appendix B

SOUTH CAROLINA
END-OF-COURSE EXAMINATION PROGRAM

Taxonomy of Cognitive Domains[1] for Physical Science and Biology

The items in the South Carolina End-of-Course Examination Program (SC EOCEP) will be classified according to content and cognitive domains. The content domains are outlined in the item specification documents; the cognitive domains are outlined below.

There are three cognitive domains—factual knowledge; conceptual understanding, which incorporates comprehension and application; and reasoning and analysis, which includes analysis, synthesis, and evaluation.[2] Each domain has been further broken down as shown below. This breakdown helps standardize the domains and gives a common set of understandings that item writers can follow as they construct their items.

The South Carolina EOCEP in Physical Science and biology consists of multiple-choice items. Although students have to recognize or identify correct answers, many such items go beyond factual knowledge. For example, the ability to recognize a valid prediction should not be thought of as simple recall, since the student must synthesize the information in order to recognize the valid prediction. It should also be noted that the difficulty level of items within each domain can vary substantially. A factual knowledge item can be very difficult, while an item that calls for a conclusion, and thus classified as measuring reasoning and analysis, can be somewhat easy depending on the context.

Factual Knowledge (FK)

Recall/Recognize
Identify accurate statements about science facts, relationships, processes, and concepts; identify the characteristics or properties of specific organisms, materials, and processes.

Define
Identify definitions of scientific terms; recognize and use scientific vocabulary, symbols, abbreviations, units, and scales in relevant contexts.

Describe
Recognize organisms, physical materials, and science processes that demonstrate knowledge of properties, structure, function, and relationships.

[1] Taken from TIMSS Assessment Frameworks and Specifications 2003.
[2] There are a number of different ways to organize cognitive domains; most are based on Bloom’s taxonomy.

Use Tools and Procedures
Demonstrate knowledge of the use of science apparatus, equipment, tools, procedures, and measurement devices/scales.

Conceptual Understanding (CU)

Illustrate with Examples
Identify specific examples to illustrate knowledge of general concepts.

Compare/Contrast/Classify
Identify similarities and differences between groups of organisms, materials, or processes; distinguish, classify, or order individual objects, materials, organisms, and processes based on characteristics and properties.

Represent/Model
Use diagrams and/or models to demonstrate understanding of science concepts, structures, relationships, processes, and biological/physical systems and cycles (e.g., food webs, electrical circuits, atomic structure).

Relate
Relate knowledge of underlying biological and physical concepts to the observed or inferred properties/behaviors/uses of objects, organisms, and materials.

Extract/Apply Information
Identify/extract/apply relevant textual, tabular, or graphical information in light of science concepts/principles.

Find Solutions
Identify/use science relationships, equations, and formulas to find qualitative or quantitative solutions involving the direct application/demonstration of concepts.

Explain
Identify reasons/explanations for observations or natural phenomena, demonstrating understanding of the underlying science concept, principle, law, or theory.

Reasoning and Analysis (RA)

Analyze/Interpret/Solve Problems
Analyze problems to determine the relevant relationships, concepts, and problem-solving steps; interpret/use diagrams and graphics to visualize and/or solve problems; give evidence of deductive and inductive reasoning processes used to solve problems.

Integrate/Synthesize
Provide solutions to problems that require consideration of a number of different factors or related concepts; make associations/connections between concepts in Physical Science and Biology;

demonstrate understanding of unified concepts and themes across the domains of science; integrate mathematical concepts/procedures in the solutions to science problems.

Hypothesize/Predict
Combine knowledge of science concepts with information from experience or observation to recognize questions that can be answered by investigation; formulate hypotheses as testable assumptions using knowledge from observation and/or analysis of scientific information and conceptual understanding; make predictions about the effects of changes in biological or physical conditions in light of evidence and scientific understanding.

Design/Plan
Recognize investigations appropriate for answering questions or testing hypotheses; recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause-and-effect relationships; make decisions about measurements/procedures to use in conducting investigations.

Collect/Analyze/Interpret Data
Make and record systematic observations and measurements, demonstrating appropriate applications of apparatus, equipment, tools, procedures, and measurement devices/scales; represent scientific data in tables, charts, graphs, and diagrams using appropriate format, labeling, and scales; select/apply appropriate mathematical computations/techniques to data to obtain derived values necessary to draw conclusions; detect patterns in data, describe/summarize data trends, and interpolate/extrapolate from data or given information.

Draw Conclusions
Make valid inferences on the basis of evidence and/or understanding of science concepts; draw appropriate conclusions that address questions/hypotheses, and demonstrate understanding of cause and effect.

Generalize
Make/evaluate general conclusions that go beyond the experimental or given conditions, and apply conclusions to new situations; determine general formulas for expressing physical relationships.

Evaluate
Weigh advantages and disadvantages to make decisions about alternative processes, materials, and sources; consider scientific and social factors to evaluate the impact/consequences of science and technology in biological and physical systems; evaluate alternative explanations and problem-solving strategies and solutions; evaluate results of investigations with respect to sufficiency of data to support conclusions.

Justify
Use evidence and scientific understanding to justify explanations and problem solutions; construct arguments to support the reasonableness of solutions to problems, conclusions from investigations, or scientific explanations.